Baseline Alternatives of the Best Available Technologies (BAT) Applicable for Remediation of Contaminated Groundwater in the X-749/X-120 Area

General Response Action	Remedial Technology Type	Process Option	Description	General Contaminant and Site Applicability	Retained/ Eliminated	Justification
				Groundwater		
No Action	None	Natural Attenuation	Processes such as dilution, dispersion, biodegradation, radioactive decay, or volatilization may naturally reduce the concentrations of some contaminants in some media.	All contaminants, all media	Retained	
Institutional Controls	Access and Use Restrictions	Physical Barriers	Fences, signs, or other barriers limit site access.	All contaminants, all media	Retained	
		Covenants/Deed Restrictions	Codes, deeds, or zoning restricts certain land uses.	All contaminants, all media	Retained	
		Industrial Requirements	Industrial policies and procedures (e.g., training, standard operating procedures, badges, guards) control employee access.	All contaminants, all media	Retained	
	Maintenance and Monitoring	Surveillance and Maintenance	Inspections of facilities and performance of preventive or corrective measures ensure proper operation of engineered controls.	All contaminants, all media	Retained	
		Monitoring	Sampling and characterization of waste, soils, surface water, groundwater, and air before, during, and after remediation verifies the effectiveness of remedial actions.	All contaminants, all media	Retained	
Containment	Hydrologic Control	Physical Barrier	Cutoff wall installed to bedrock surface to prevent contaminant migration	All contaminants, all media	Retained	
In Situ Treatment	Physical/Chemical Treatment	*Reactive Barriers/ Reactive Gates	A trench filled with appropriate reactive or sorbent material (e.g., granular activated carbon, ion exchange resin, or ceramic foam) can remove contaminants from groundwater flowing through the barrier. Process option includes DNAPL sorbents in trenches. Can also be combined with slurry walls.	All contaminants (with appropriate material) in shallow subsurface water	Eliminated	Not effective for achieving risk reduction to an acceptable range in all areas.
In Situ Treatment (continued)	Physical/Chemical Treatment	Air Sparging	Air injected into groundwater enhances volatilization. Coupled with collection and treatment of gases and condensate.	Volatiles in groundwater	Eliminated	Not effective in reducing VOC contamination in low permeability formations.

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		Vertical Circulation Systems	Wells with screens near the bottom and top of a single aquifer can be operated to circulate water vertically in the aquifer and treat water within the well and possibly within the aquifer. Air-lift pumping and air stripping by using a blower and submersible pump can draw water into the well and strip VOCs from the water as air bubbles rise through the water column. Nutrients, oxygen, electron acceptors, and other soluble reagents can be added through the well to the groundwater within the aquifer to enhance bioremediation or other in situ treatment. Filters, bioreactors, catalysts, or other devices can be placed in the well for sorption or degradation of contaminants.	VOCs, nitrate, NAPLs, possibly other organic or inorganic contaminants in groundwater within the radius of influence of the circulation well	Eliminated	High levels of iron in groundwater can foul in well screens. Recirculation system may be used in conjunction with oxidant injection.
		Soil Flushing	Water, aqueous solutions, or acids are used to dissolve contaminants in the soil matrix. Contaminated elutriate is collected and pumped to the surface for removal or onsite treatment and reinjection.	Organics, Hg, other inorganics in soil	Eliminated	Not as effective in low permeability soils. Most effective when combined with soil excavation and media not contaminated with radionuclides.
		*Electrokinetics	Low-level direct current applied through electrodes in soil creates an acid front at the anode and mobilizes contaminants toward the cathode through the mass transfer mechanisms of advection, diffusion, and ion migration. Contaminants must then be removed, treated, and disposed.	Metals and some organic compounds	Eliminated	Not practical in highly industrialized setting. Not effectively demonstrated for all contaminants present.
In Situ Treatment (continued)	Physical/Chemical Treatment	*LASAGNA™	LASAGNA™ is a combination of treatment components that permits in situ treatment of contaminants by creating higher permeability soil environments. Used in concert with electrokinetics.	Metals and some organic compounds	Eliminated	Still in demonstration stage of development.
	Biological	Phytoremediation	Continuous passive treatment by use of vegetation to act as a pump for groundwater extraction and biological treatment. Also, limits surface recharge.	VOCs, certain SVOCs, and PCBs. Certain compounds can inhibit process	Retained	May be used in selected areas.
		Enhanced Bioremediation	Bacteria/algae are used for in situ conversion of compounds or to immobilize the contaminant.	Chlorinated compounds	Retained	
Ex Situ Treatment	Pump and Treat	Extraction wells	Contaminated groundwater can be pumped from an array of vertical, horizontal, or inclined well points, suction wells,	Contaminants that are miscible and move readily	Retained	

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			ejector wells, or deep wells.	with water; inorganics		
		VER Process	A high vacuum (20 - 28 in. Hg) drawn through a well installed below the water table can strip volatile contaminants in groundwater and saturated and unsaturated soils from the aqueous phase into the vapor phase. Vapor-phase treatment (e.g., granular activated carbon) or other treatment systems can be included above ground. Typically used in combination with groundwater extraction.	VOCs in groundwater and soil. Effective in moderate to low permeability formations	Retained	
	Water Treatment Contaminant Removal/ Concentration	*Hydraulic Fracturing	Fracturing emplaces propped horizontal fractures on vertical spacings of approximately 1 in. Fractures serve as conduits for delivery of pressurized hot air or steam.	Contaminants in soil or water	Eliminated	Not practical because of existing facilities in industrialized area.
		Chemical Reduction/Oxidation	Contaminants are either destroyed or converted to more easily handled form by addition of oxidation agents (e.g., hydrogen peroxide, ozone, etc.) or reducing agents (e.g., ferrous sulfate, sulfur dioxide, etc.).	Metals, inorganics, organics, radionuclides	Retained	
Ex Situ Treatment (continued)	Water Treatment Contaminant Removal/ Concentration (continued)	Liquid Phase Adsorption	Water is pumped through a series of vessels containing sorbent to which contaminants are adsorbed. Potential adsorbents include granular activated carbon, Amersorb®, and sulfur-impregnated carbon. Granular Activated Carbon is a well-established, regenerable sorbent for VOCs. Amersorb® is a regenerable adsorption system with synthetic adsorbent 5 to 10 times capacity that of granular activated carbon.	VOCs in water, low concentrations of Hg in water	Retained	
		Air Stripping	Countercurrent mixing of large volumes of air with water to promote transfer of VOCs to air. VOC-contaminated water can be removed and stripped in an existing cooling tower onsite.	Volatiles (Henry's law constant > 0.003) in water	Retained	
		Aerobic Biological Treatment	Aerobic biological wastewater treatment processes employ microorganisms, principally bacteria, that can use wastewater contaminants as part of their metabolism. The contaminants are thereby removed from the wastewater or transformed into a benign form. The primary mechanism of removal is oxidation with molecular oxygen serving as the oxidant or electron acceptor. The contaminant compounds serve as the electron	VOCs	Eliminated	Not cost effective method for treatment of extracted groundwater. Retained as an in situ technology.

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			donors and are typically referred to as substrates. The microorganisms obtain energy from mediating these redox reactions and use this energy to maintain cells and synthesize new cells or biomass.			

DNAPLs = Dense nonaqueous phase liquids
NAPLs = Nonaqueous phase liquids
PCBs = Polychlorinated biphenyls
SVOCs = Semivolatile organic compounds
TCE = Trichloroethene
VOCs = Volatile organic compounds
* = may be considered during CMI if additional data are available